WHAT IS CLAIMED IS:

1. A method of forming a swirl unit of a spray nozzle comprising the steps of:

providing a sheet of material for forming the swirl disk therefrom;

forming at least one swirl disk from the sheet of material by (1) removing material about a peripheral portion of the swirl disk and, in turn, forming a peripheral edge of the swirl disk, (2) removing material from at least one first region of the swirl disk spaced inwardly relative to the peripheral edge of the swirl disk and, in turn, forming a first aperture extending through the first region and defining a swirl chamber, and (3) removing material from at least one second region of the swirl disk extending between the swirl chamber and peripheral edge of the swirl disk and, in turn, forming a second aperture extending through the second region and defining a flow inlet to the swirl chamber.

2. A method as defined in claim 1, further comprising the step of providing an orifice disk for use with the swirl disk of the spray nozzle, wherein the step of providing the orifice disk includes:

providing a sheet of material for forming the orifice disk therefrom;

forming at least one orifice disk from the sheet of material by (1) removing material about a peripheral portion of the orifice disk and, in turn, forming a peripheral edge of the orifice disk, and (2) removing material from at least first region of the orifice disk spaced inwardly relative to the peripheral edge of the orifice disk and, in turn, forming a first aperture extending through the first region and defining a spray orifice.

3. A method as defined in claim 2, further comprising the steps of (1) providing a retaining body defining an inlet aperture and an outlet aperture for discharging a spray therefrom; (2) mounting the orifice disk within the retaining body with the spray orifice aligned with and adjacent to the outlet aperture; (3) mounting the swirl disk within the retaining body adjacent to the orifice disk with the swirl chamber aligned with and coupled in fluid communication to the spray orifice of the orifice disk; and (4) providing a fluid communication path between the inlet aperture of the retaining body and the flow inlet to the swirl chamber for directing fluid flowing through the inlet of the retaining body into the inlet of the swirl chamber, creating a swirling flow of fluid upon entering the swirl chamber, and discharging the fluid through spray orifice in a spray pattern emanating therefrom.

4. A method as defined in claim 3, further comprising the steps of (1) providing a plug defining at least one fluid conduit; (2) fixedly securing the plug into the retaining body and, in turn, fixedly securing with the plug the swirl disk and orifice disk in the retaining body; and (3) providing a fluid communication path between the inlet aperture of the retaining body and the spray orifice of the swirl disk defined by the least one fluid conduit of the plug, an annulus formed between the plug and the retaining body, and the inlet of the swirl disk and the swirl chamber, wherein the fluid flows from the inlet of the retaining body through the at least one fluid conduit of the plug, through the annulus between the plug and retaining body, through the inlet of the swirl disk, through the swirl chamber which, in turn, causes the fluid to flow in a vortex, and through the spray orifice wherein the fluid is discharged as droplets in a spray pattern.

5. A method as defined in claim 4, further comprising the step of providing a plug defining at least one flat, wherein the flat defines a fluid flow path between the plug and retaining body and extending between the inlet of the retaining body and the annulus for fluid flow therebetween.

6. A method as defined in claim 4, further comprising the step of providing a plug defining at least one fluid conduit formed therein and at least one exit aperture connected in fluid communication with the at least one fluid conduit, and providing a fluid flow path from the inlet of the retaining body, through the at least one fluid conduit of the plug, through the at least one exit aperture of the plug, and into the annulus.

7. A method as defined in claim 1, wherein each step of removing sheet material is performed by etching.

8. A method as defined in claim 4, further comprising the step of providing a filter adjacent to the plug for preventing contaminants from entering the spray nozzle.

9. A method as defined in claim 1, further comprising the step of forming the swirl disk with a first substantially planar surface on one side of the swirl disk, and a second substantially planar surface formed on an opposite side of the swirl disk.

10. A method as defined in claim 1, further comprising the step of forming the first and second sides of the swirl disk substantially symmetrical about a plane perpendicular to an axis of the swirl disk.

11. A method as defined in claim 10, further comprising the step of forming the first and second surfaces of the swirl disk substantially identical.

12. A method as defined in claim 1, further comprising the step of applying a wear-resistant coating to one or more surfaces of the swirl disk.

13. A method as defined in claim 2, further comprising the step of applying a wear-resistant coating to one or more surfaces of the orifice disk.

14. A spray nozzle comprising:

a body defining an inlet aperture and an outlet aperture;

an orifice disk receivable within the body adjacent to the outlet aperture and including a sheet material substrate defining a first surface formed on one side of the substrate, a second surface formed on an opposite side of the substrate relative to the first surface, a side surface extending between the first and second surfaces and defining a peripheral edge of the orifice disk, and a spray orifice extending through a first region of the substrate spaced inwardly relative to the peripheral edge;

a swirl disk receivable within the body adjacent to the orifice disk and including a sheet material substrate defining a first surface formed on one side of the substrate, a second surface formed on an opposite side of the substrate relative to the first surface, a side surface extending between the first and second surfaces and defining a peripheral edge of the swirl disk, a swirl chamber defined by a first aperture extending through a first region of the substrate spaced inwardly relative to the peripheral edge, and a swirl inlet defined by a second aperture formed through a second region of the substrate extending between the swirl chamber and peripheral edge; and

a retaining member receivable within the body adjacent to the swirl disk for retaining the swirl disk and orifice disk within the body, wherein the retaining member defines a fluid flow path coupled in fluid communication between the inlet of the body and the inlet of the swirl disk for directing fluid flowing through the inlet of the body into the swirl chamber and,

in turn, imparting a swirling flow to the fluid prior to discharging the fluid through the spray orifice in spray pattern emanating therefrom.

15. A spray nozzle as defined in claim 14, further comprising a filter receivable within the body in fluid communication with the fluid flow path defined by the retaining member for filtering fluid flowing through the inlet aperture of the body prior to passage through the swirl chamber.

16. A spray nozzle as defined in claim 14, wherein the peripheral edge of the swirl disk defines at least two locating surfaces for contacting an interior surface of the body and aligning the swirl disk within the body.

17. A spray nozzle as defined in claim 14, wherein the peripheral edge of the orifice disk defines at least two locating surfaces for contacting an interior surface of the body and aligning the orifice disk within the body.

18. A spray nozzle as defined in claim 14, wherein the retaining member defines at least one flat spaced inwardly relative to the body and defining the fluid flow path therebetween.

19. A spray nozzle as defined in claim 14, wherein the retaining member defines an aperture extending therethrough and at least one exit orifice coupled in fluid communication with the aperture for passing fluid therethrough.

20. A spray nozzle as defined in claim 14, wherein the first and second surfaces of the swirl disk are substantially symmetrical about a plane approximately perpendicular to an axis of the swirl disk.

21. A spray nozzle as defined in claim 20, wherein the first and second surfaces of the swirl disk are substantially identical.

22. A spray nozzle as defined in claim 14, wherein the first surface of the swirl disk is substantially planar throughout.

23. A spray nozzle as defined in claim 22, wherein the second surface of the swirl disk is substantially planar throughout.

24. A spray nozzle as defined in claim 14, wherein the swirl disk defines a plurality of swirl chambers, the orifice disk defines a plurality of spray orifices, and each swirl chamber is located adjacent to and coupled in fluid communication with a respective spray orifice.

25. A spray nozzle as defined in claim 24, wherein at least one of the body and the swirl disk defines a locating surface, and the other of the body and the swirl disk defines a locating recess for receiving the locating surface and thereby locating the swirl disk within the body.

26. A swirl disk for a spray nozzle comprising:

a sheet material substrate defining a first surface formed on one side of the substrate, a second surface formed on an opposite side of the substrate relative to the first surface, a side surface extending between the first and second surfaces and defining a peripheral edge of the swirl disk, a swirl chamber defined by a first aperture extending through a first region of the substrate spaced inwardly relative to the peripheral edge, and a swirl inlet defined by a second aperture formed through a second region of the substrate extending between the swirl chamber and peripheral edge.

27. A swirl disk as defined in claim 26, wherein the first and second surfaces are substantially symmetrical about a plane approximately perpendicular to an axis of the swirl disk.

28. A swirl disk as defined in claim 27, wherein the first and second surfaces are substantially identical.

29. A swirl disk as defined in claim 26, wherein at least one of the first and second surfaces is substantially planar throughout.

30. A swirl disk as defined in claim 26, wherein the swirl chamber defines a throat ratio of approximately 3:5 through approximately 11:10.

31. A swirl disk as defined in claim 26, further defining a plurality of swirl chambers and a plurality of corresponding swirl inlets, wherein each swirl inlet extends between a respective swirl chamber and a peripheral edge of the swirl disk.

32. A swirl disk as defined in claim 26, in combination with an orifice disk comprising:

a sheet material substrate defining a first surface formed on one side of the substrate, a second surface formed on an opposite side of the substrate relative to the first surface, a side surface extending between the first and second surfaces and defining a peripheral edge of the orifice disk, and a spray orifice extending through a first region of the substrate spaced inwardly relative to the peripheral edge.

33. A swirl disk for a spray nozzle comprising:

a sheet material substrate defining a first surface formed on one side of the substrate, a second surface formed on an opposite side of the substrate relative to the first surface, a side surface extending between the first and second surfaces and defining a peripheral edge of the swirl disk, first means extending through a first region of the substrate spaced inwardly relative to the peripheral edge for forming a swirling flow of fluid within the swirl disk, and second means extending between the first means and peripheral edge for directing fluid into the first means.

34. A swirl disk as defined in claim 33, wherein the first means is defined by a first aperture extending through the swirl disk and forming a swirl chamber therein.

35. A swirl disk as defined in claim 33, wherein the second means is defined by a second aperture extending through the swirl disk and defining a flow inlet extending between the first means and a peripheral edge of the swirl disk.

36. A swirl disk as defined in claim 33, in combination with an orifice disk comprising:

a sheet material substrate defining a first surface formed on one side of the substrate, a second surface formed on an opposite side of the substrate relative to the first surface, a side surface extending between the first and second surfaces and defining a peripheral edge of the orifice disk, and a spray orifice extending through a first region of the substrate spaced inwardly relative to the peripheral edge.

37. A swirl disk and orifice disk as defined in claim 36, wherein the first means is defined by a first aperture extending through the swirl disk and forming a swirl chamber therein.

38. A swirl disk and orifice disk as defined in claim 36, wherein the second means is defined by a second aperture extending through the swirl disk and defining a flow inlet extending between the first means and a peripheral edge of the swirl disk.

39. A swirl disk as defined in claim 26, wherein the swirl disk defines a thickness within the range of about 0.003 inches through about 0.03 inches.

40. A swirl disk as defined in claim 39, wherein the swirl disk defines a thickness within the range of about 0.005 inches through about 0.015 inches.

41. A swirl disk as defined in claim 26, wherein the swirl disk further defines a throat formed between the swirl inlet and swirl chamber, the swirl chamber defines a start radius, and the ratio of the throat divided by the start radius is within the range of about 0.6 through about 1.1.

42. A swirl disk and orifice disk as defined in claim 32, wherein the orifice disk defines a thickness within the range of about 0.005 inch through about 0.03 inch.

43. A swirl disk and orifice disk as defined in claim 32, wherein the ratio of the axial depth of the spray orifice (L) to a diameter of the spray orifice (D) is within the range of about 0.16 through about 6.

44. A swirl disk and orifice disk as defined in claim 36, in further combination with:

a body defining an inlet aperture and an outlet aperture, wherein the orifice disk is receivable within the body with the spray orifice aligned and coupled in fluid communication with the outlet aperture of the body; and

means for securing the swirl disk and orifice disk within the body.

45. A swirl disk, orifice disk and body as defined in claim 44, wherein the means for securing is defined by a plug receivable within the body for fixedly securing the swirl disk and orifice disk within the body.

46. A swirl disk for a spray nozzle formed in accordance with a method comprising the steps of:

providing a sheet of material for forming the swirl disk therefrom;

forming at least one swirl disk from the sheet of material by (1) removing material about a peripheral portion of the swirl disk and, in turn, forming a peripheral edge of the swirl disk, (2) removing material from at least one first region of the swirl disk spaced inwardly relative to the peripheral edge of the swirl disk and, in turn, forming a first aperture extending through the first region and defining a swirl chamber, and (3) removing material from at least one second region of the swirl disk extending between the swirl chamber and peripheral edge of the swirl disk and, in turn, forming a second aperture extending through the second region and defining a flow inlet to the swirl chamber.

47. A spray nozzle comprising:

a retaining body;

an orifice disk receivable within the retaining body and defining a spray orifice;

a sheet material substrate receivable within the retaining body adjacent to the orifice disk and defining a first surface formed on one side of the substrate, a second surface formed on an opposite side of the substrate relative to the first surface, a side surface extending between the first and second surfaces and defining a peripheral edge of the swirl disk, first means extending through a first region of the substrate spaced inwardly relative to the peripheral edge for forming a swirling flow of fluid within the swirl disk, and second means

extending between the first means and peripheral edge for directing fluid into the first means; and

third means for securing the orifice disk and spray disk within the retaining body.

48. A spray nozzle as defined in claim 47, wherein the third means defines a fluid flow path coupled in fluid communication between an inlet of the body and the second means of the swirl disk.

49. A spray nozzle as defined in claim 48, wherein the fluid flow path is defined by an annulus formed between the third means and the body.

50. A spray nozzle comprising:

a body defining an integral side wall, an inlet aperture formed at one end of the body, an integral end wall located at an opposite end of the body relative to the inlet aperture and defining on an interior side thereof a substantially planar peripheral surface, a swirl chamber defined by a first recess formed within the substantially planar peripheral surface and defining a curvilinear side wall for creating a swirling flow of fluid within the recess, and a swirl inlet defined by a second recess formed within the substantially planar peripheral surface, wherein the swirl inlet defines on an interior end thereof a relatively narrow throat connecting the swirl inlet in fluid communication with the swirl chamber, and wherein the swirl inlet increases in width in the direction from the throat toward a peripheral portion of the substantially planar surface, and wherein the integral end wall of the body defines a spray orifice extending through the end wall in fluid communication with the swirl chamber for receiving the swirling fluid from the swirl chamber and discharging the fluid in a spray pattern emanating therefrom; and

a plug receivable within inlet aperture of the body and defining a fluid flow path connectable in fluid communication between the inlet aperture of the body and the swirl inlet for directing fluid flowing through the inlet aperture of the body to the swirl inlet, into the swirl chamber, and through the spray orifice in spray pattern emanating therefrom.

51. A spray nozzle as defined in claim 50, wherein the body is formed by metal injection molding.

52. A spray nozzle as defined in claim 50, wherein the swirl chamber defines a throat ratio of approximately 3:5 through approximately 11:10.